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SEWAGE TREATMENT PLANT DEPENDABILITY WITH SPECIAL REFERENCE TO THE ACTIVATED SLUDGE PROCESS

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to the

ACTIVATED SLUDGE PROCESS

by

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SEWAGE TREATMENT PLANT DEPENDABILITY

With Special Reference to the

ACTIVATED SLUDGE PROCESS

INTRODUCTION

This report has been developed as a reference for Plant Dependability lectures that the writer has presented at training sessions, symposia and workshops. It is based on first-hand operational experiences at dozens of sewage treatment plants; and covers design features and operational procedures that have governed plant performance and final effluent quality. This is not a statement of Environmental Protection Agency policy or requirements; it is an expression of the writer's personal convictions regarding treatment plant design and operation concepts.

DESIGN CONSIDERATIONS

To achieve consistently satisfactory plant performance and final effluent quality, designers should:

Select the proper treatment process,

Provide generous capacity,

Provide essential flexibility, and

Make the plant truly controllable.

A. TREATMENT PROCESSES

Early in the design stage, the engineer must exercise his best experienced professional judgment in selecting the treatment process or modification most appropriate to the known waste characteristics and effluent quality requirements. Process features to be evaluated would include, for example:

1. The Classic Activated Sludge Process design, conforming generally to "10-States Standards," usually performs satisfactorily for normal municipal wastes where domestic sewage predominates.

   It is defined as the original activated sludge system; all return sludge and all settled sewage enters the head end of the aeration tanks.

2. The Complete Mix modification has been found admirably suited for mixtures of domestic sewage and industrial wastes with highly variable characteristics and concentrations.

3. The Step Aeration modification permits an operator to select and change his basic process cycle to accommodate unexpected overloads, to adjust sludge solids distribution and to control mixed liquor sludge characteristics.

   To be truly effective the Step design must permit controlled, measured incremental sewage discharge to each aerator pass or compartment. It must also permit the discharging of all sewage into either the first or the last pass of the aeration tanks. The design should permit operation in either Classic, Step or Contact-Stabilization mode in response to plant loading and process demands.

B. PILOT STUDIES

These studies may be needed to resolve uncertainties. The extent of such pilot studies will depend upon effluent requirements, the specific information needed, and the size, complexity and cost of the treatment facilities to be constructed.

1. Bench Scale.

   Waste treatability studies can be performed effectively and economically at Bench Scale.

2. Pilot Scale.

   A specially constructed small pilot plant (possibly 0.1 MGD or more capacity) may be needed if additional essential information is required. Such units can validate process suitability, relative tank sizes, and system dynamics for the proposed full size plant.

3. Demonstration Scale.

In some cases, full sized plant units must be utilized to demonstrate the relative effectiveness of different types or arrangements of plant equipment. For example, it is impractical if not impossible to prove the suitability of various overflow weir arrangements for 150 ft. diameter final clarifiers from studies on 10-ft. diameter pilot scale models. At times certain units in existing plants can be modified for such study before the design of plant additions is initiated.

C. PLANT CAPACITY

Design criteria such as the "10-States Standards" and others should be interpreted skillfully and used as intended. In other words, most suggestions in such manuals should be considered as minimum requirements needed to provide adequate safety factors to assure plant dependability. Generous capacity is always welcomed by plant operators and by plant managers facing the necessity for day-in, day-out, dependable and acceptable plant performance and effluent quality. What seems surplus capacity today will in most cases be used up rapidly as communities experience rapid population growth and the unpredictable development of new waste-producing industries.

1. The twenty-four hour design capacities should be based on the averages anticipated during the maximum flow and load-producing week of the year. Obviously, any abnormally high short-term peak loads that can be anticipated must also be included in the design loading.

2. Design capacity should permit satisfactory plant performance at full load with either one aeration tank or one final clarifier out of service for maintenance. In a four-tank design, for example, clarifiers must be designed so that three of the four can successfully handle the estimated total design flow. Similarly, aeration capacity must be large enough so that three of the four aerators can handle the total estimated design load.

3. Multiple aerators and clarifiers, preferably four each for medium to large plants with capacities in excess of 15.0 MGD, should be provided. This is, of course, a corollary to "2".

4. Plant recycle (thickener overflow, sludge filtrate, dilution flows, etc.) must be included in the design load. Such recycle flows can readily exceed ten percent and even approach twenty percent of design flows. These additional flows will influence aeration tank organic loadings, detention times, and final clarifier overflow rates.

5. Sludge handling facilities must be designed to accommodate not the average but the maximum anticipated sludge quantities even when units are down for maintenance. Sludge wasting requirements at activated sludge plants can vary greatly from day to day in response to sewage loads, process equilibrium, and mixed liquor sludge quality. At times, extremely high wasting rates, greatly in excess of the anticipated average, will be needed to restore equilibrium to a system when it is sliding out of balance.

6. Generous sludge holding-equalizing tank capacity is essential and can reduce substantially the danger of periodic overloading of sludge processing equipment.

D. FLEXIBILITY

The plant should be designed to provide maximum operating flexibility.

1. Process

   a. If the activated sludge process is selected for secondary treatment, evaluate the relative advantages of both the Classic process and the Complete Mix modification for the type and characteristics of the incoming raw wastes as well as the plant performance required to meet final effluent and receiving water quality objectives.

   b. Provide for Step operation of any Classic activated sludge system.

   c. Be sure any Step design can be operated in all modes, from Classic, through variable Step proportions, to Contact-Stabilization.

   d. Where practical, provide each group of aerators and clarifiers with its own separate return and waste sludge pumping facility.

2. Aeration Tanks

   a. Provide truly effective mixing and oxygenation.

   b. Guard against "coreing" and "dead areas" in aerators. Don't compromise by making ineffective modifications of basically inappropriate aeration devices.

   c. Provide truly controllable, measurable, variable outputs for mechanical aerators or air blowers.

d. Provide separate, controllable, metered air headers for each pass or compartmented zone of the aeration tank. For example, don't connect the "A" pass (with its relatively high air demand) of one aerator and the "C" pass (with its relatively low air demand) of an adjacent aerator to a common air header.

e. Consider providing recording D.O. meters. (Preferably actuating air blower controllers.)

f. Consider providing mixed liquor and return sludge solids concentration sensors and recorders.

3. Final Clarifiers

a. Obviously, minimize excessive velocity currents and short-circuiting.

b. Provide generous surface area. Contemporary high capacity designs appear to require considerably more surface area than suggested by the conventional 800 Gals./Day/Sq.Ft. overflow rate requirement.

c. For large tanks, certainly for those 100 feet in diameter and greater, provide appropriately located and properly spaced multiple effluent weir launders.

d. Provide effective surface scum collection and removal devices.

e. Consider 12 feet as a minimum practical side wall depth. Despite calculable theory, shallow tanks aggravate floc carry-over characteristics.

f. Provide combination suction-scraper sludge collectors to minimize clarifier sludge detention time. Be sure that actual sludge withdrawal capacity equals 100 percent of design waste flow plus recycle.

4. Return Sludge Pumping Facilities

a. Provide multiple remotely adjustable return sludge pumps. Pumping capacity should equal 100 percent of design waste plus recycle flow when the largest pump is taken out of service for maintenance.

5. Excess Sludge Wasting

   a. Provide separate metered, controllable waste sludge pumps.

   b. Be sure they can be operated satisfactorily at the low wasting rates that will be required at times. (A valved interconnection to the return sludge pumping system can accommodate the exceptionally high wasting demands that occur occasionally.)

   c. Provide a suitable valved interconnection to permit wasting either from the aerator outlet (mixed liquor) or from the clarifier sludge withdrawal system (return sludge).

6. Emergency Chemical Treatment

   a. Provide feeders, meters, controllers, and piping to permit emergency application of metallic salts and polymers to aerators or clarifiers as well as to primary tanks.

7. Adjunct Facilities

   a. Sludge Handling Facilities

      1) Must be designed to handle not average but maximum anticipated loads even with units down for maintenance.

      2) Must be provided with generous storage or equalizing tanks to accommodate periodic peak requirements that will at times exceed even estimated maximum loads.

      3) Must provide means to dispose of partially processed sludge during breakdowns.

         a) Sludge thickening - filtering - burning. Be sure filtered sludge can be collected, conveyed out of the building and hauled away in case of serious furnace breakdown.

         b) Sludge Digestion - Provide facilities to collect, pump, and haul supernatant and partially digested sludge to prescribed disposal areas.

         c) Plan an "out" so that the secondary process and effluent quality need not be degraded by the breakdown of other plant facilities.

b. Equalizing Tanks

Provide equalizing and flow regulating tanks where concentrated industrial wastes enter the plant through separate sewers.

c. Holding Ponds

Consider holding ponds for effluent polishing or for storing and recycling primary effluent during severe plant overloading.

E. CONTROLLABILITY

1. Meters

The activated sludge system is a controllable process that must include appropriate meters and accurately controllable gates, valves, pumps and blowers for optimum performance.

a. Obviously the most reliable proper meters should be specified.

b. A single subcontractor should supply and be fully responsible for the satisfactory performance of the entire meter-controller package.

c. A qualified instrument technician should be included on the staff of all large plants.

At smaller plants a capable technician, from within the community if possible, should be retained for periodic meter maintenance and emergency repair.

d. A separate independent meter should be provided at each plant unit requiring control adjustment.

A summator, in addition to read-out from individual meters, is helpful for multi-unit plants. But beware of a subtractor as the sole means of obtaining an essential third flow measurement from two other independent meters.

e. Individual meters and control gates should be provided in critical areas. Beware of relying too greatly on so-called, hydraulic similitude for balancing flows between multiple units.

f. When a design includes a phased series of future additions, the meters provided for Phase I must be small enough to permit accurate measurement of the relatively low initial flows. When pipes are sized for future additions, it may be necessary to install replaceable meters in temporarily reduced pipe sections.

g. The total metering package should be adequate to permit accurate control adjustments, to maintain balance in multiple parallel plant units, to document plant performance, and to permit process and effluent quality evaluation.

1) Measure either plant influent or effluent separately. A back-up sensor and indicator on the other end will be useful. Do not depend on mechanical addition of other internal meters for this value.

2) Be sure that waters recycled within the plant are metered and can be accounted for.

3) Provide individual meters for each of the following similar parallel plant features. (i.e. Four meters for influent flow to four parallel aerators.)

a) Return Sludge Flow:

to each Aerator, from each Clarifier.

b) Waste Water Flow:

to each Aerator, to each pass in "Step"*

from each Clarifier**.

c) Mixed Liquor Flow:

to each Clarifier.

d) Air Discharge:

to each Aerator, to each "pass" of each Aerator*.

e) Waste Sludge:

one meter for each individual aerator-clarifier battery.

* Can be calibrated manometers or simple indicating meters.

** Desirable, but can be eliminated if all other meters are provided.

2. Meter-Control Panel

a. General

In large multi-unit plants it is utterly impractical to adjust or balance flows manually at valve or pump locations that are far removed from the meter panels. A centrally located meter-control panel, wired to mechanical valve and pump actuators, permits accurate adjustment of critical flows while the response is being observed on the meters.

b. Remotely actuated controllers should be provided for:

1) Controlling return and waste sludge pumps.

2) Proportioning waste water and return sludge flows to individual aerators.

3) Proportioning mixed liquor flow to, and return sludge withdrawal from, individual clarifiers.

3. Automatic Controllers

a. General

Density sensors coupled to automatic controllers should be provided as part of the adjunct sludge handling and disposal facilities. Such control, according to the operator's "set point" requirements, greatly improves the performance of units like the sludge thickener, and digester, and minimizes the supplementary recycle load on the secondary treatment facilities.

b. Other automatic controllers that should be considered include:

1) D.O. sensor actuated blower controllers to regulate air discharge rates.

2) Meter actuated controllers to proportion return sludge pumpage according to the cyclic incoming waste water flow rates.

3) Mixed liquor and return sludge concentration sensor actuated controllers to adjust return sludge pumping and solids distribution.

OPERATIONAL CONTROL

Any discussion of the relative importance of operator or designer qualifications would be academic at best. However, it is unquestionably true that qualified operators are needed to achieve the high quality effluent that can be produced by properly designed waste treatment plants. Of even greater importance is the ingenuity of dedicated, experienced operators needed at plants that suffer from design defects.

The following management and operations procedures contribute immeasurably to best plant performance.

A. PERSONNEL

1. Hire the best qualified people available.

2. Support Operator Certification programs strongly.

3. Send selected personnel to training courses and to similar treatment plants to upgrade their knowledge.

4. Conduct continuing in-house training.

5. Inspire all operators to recognize that consistent production of the best possible final effluent quality is their most important professional responsibility.

6. Select a qualified senior staff member as the designated process control supervisor.

7. Provide the tools and facilities the staff needs to accomplish its objective.

B. DUTY DELEGATION

1. Delegate responsibility for safety, preventive maintenance, and emergency repair duty.

2. Conduct critical reviews of routine operating procedures. Minimize less important activities to provide additional time for the more essential and productive operational tasks.

3. Be sure crew chiefs are fully aware of their specific responsibilities and authority. Excess sludge wasting schedules, for example, are dictated by process and effluent quality requirements. Wasting adjustments should, therefore, be directed by the secondary process crew chief, not by, except in extreme emergency, the crew chief in charge of sludge handling.

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4. Written Standing Orders and Special Instructions should be posted in the control office to avoid confusion among shift operators coming on duty around the clock.

C. CONTROL TESTS

1. Test samples must be collected properly and conscientiously.

2. Essential control tests should be run at least once every 8-hour shift, usually at 6:00 AM, 2:00 PM and 10:00 PM, and more frequently when necessary.

3. The control test series for activated sludge should include the following:

   a. Aeration Tank D.O.

   b. Clarifier sludge blanket depth.

   c. Final effluent turbidity.

   d. Mixed liquor sludge concentration and settleability.

   e. Return sludge concentration.

4. Process control demands should be calculated from the results of each test series to describe process status and dictate the type and magnitude of control adjustments needed to maintain or restore proper process performance.

D. PROCESS RELIABILITY

1. The senior staff member directing process control operations should:

   a. Daily summarize and evaluate all essential control test data, the results of demand calculations, and the extent of control adjustments.

   b. Develop running trend charts illustrating significant features of plant performance like:

      1) Plant loading,

      2) sludge settling characteristics,

      3) sludge concentration characteristics,

      4) sludge blanket depths, and

      5) final effluent turbidity.

c. Study trend charts and determine cause-effect relationships between process control and plant performance to:

1) Document loadings or control procedures that have caused trouble and must be avoided in the future.

2) Identify procedures that have proved successful and should be continued.

2. By conscientious, intelligent application of the basic operational requirements discussed previously, the director of a properly designed treatment plant will achieve consistently reliable plant performance and excellent final effluent quality.

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